Cunningham (J. D.)

DEFECTIVE VISION,

And the Principles on which it may be

CORRECTED BY OPTICAL MEANS.

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Corrected by Optical Means.

Read by Appointment before the Medical Society of Virginia, at the Annual Session in Staunton, November 20th, 1872.*

By F. D. CUNNINGHAM, M.D., Prof. Anatomy, Medical College of Va.

The fact that people wear spectacles to improve their sight is of such every day occurrence that it excites no remark; and to be told by some friend to get a pair of glasses, is the fate of nearly every one, male or female, who is fortunate enough to pass the meridian of life, and unfortunate enough to realize the effect of advancing years in the impairment of a most important special sense. If the friendly advisor is asked what kind of glasses should be obtained, he either kindly volunteers the loan of a pair which were once used by a person of the same age, or else recommends a jeweller who keeps a stock where one can be selected to suit the case. The advice given under such circumstances, and in ignorance of the physiological changes which have occurred in the organ at fault, is often followed, and with satisfactory results. At other times a wrong glass is selected, or, else, yielding to the pride of appearance, the advice is persistently rejected, to the constant discomfort of the individual, and often, perhaps, to the serious detriment of his eyesight.

The above illustration applies to one and the most common class of cases, where defective vision can be remedied by the use of glasses; but there are many others, in which a similar hap-hazard selection of the remedy might, with much more certainty, result in serious consequences. Thanks to the researches of modern ophthalmic surgeons, we now speak knowingly of these departures from a proper anatomical structure or physiological condition which produce such defects of vision as are remediable by optical means; and, with the dissemination of this knowledge, we hope the time will soon come when the profession generally will feel it incumbent on them to prescribe such agents with all that care and judgment exercised in prescribing articles of the materia medica that may be potent for both good and evil.

In the course of the following pages, we propose to consider the most common

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* During the reading of these remarks the subject was still further illustrated by reference to appropriate diagrams, and by the performance of suitable experiments; and, at the request of the Society, a practical demonstration was given in the form of a clinical lecture from material furnished by several of the members in attendance.

forms of defective sight which admit of improvement by mechanical appliances, some of the forms and varieties of these appliances, and their practical application for the relief of particular classes of cases; and, whilst doing this, we hope to establish some general rules for reference in many questions involving the hygiene of vision. Claiming no originality as to the subject matter of our remarks, we would state at the outset that it may be found in the recent standard works of the eye; and our paper is submitted, not as an original essay, but rather as an epitome of our present knowledge on many points of interest, which some before me may not have had time to fully investigate, whilst engrossed with the duties and cares of general practice.

Presuming that my hearers are familiar with the anatomical structure of the eyeball, the nature of its investments or tunics, and its refracting media, as well as with the properties of optical lenses, they are prepared for the time-honored comparison of this organ to the optical apparatus known as the camera obscura, of which the screen is represented by the retina, and on which is formed a diminished and inverted image of the external object. This comparison, in many respects, is a proper one, and, without a knowledge of optics, we would be unable to understand the most ordinary principles of the physiology of vision. But whilst the older writers spoke in glowing terms descriptive of what they considered the most perfect of all optical instruments, they at the same time originated theories about vision and its defects, which, though they had no foundation in fact, have left a decided impression on the popular mind. The organ of vision, whilst under the influence of many of the same physical laws, differs in many particulars from any known optical instrument, some of which contribute to its perfection, whilst others have a contrary effect, and in some instances may even prove sources of disease. Among these differences we may enumerate—first, the great extent of the field of vision enjoyed by the eye, ranging over 160 degrees from side to side, and over 120 degrees from above downward. Whilst endowed with this extensive field of vision, we find that perfect definition of the object is confined to a very small space, corresponding with the centre of the field, and from which rays are focussed on the "yellow spot of the retina." Outside of this small space the image is but imperfectly defined, and the indistinctness increases as we approach the periphery of the field. In this respect we have a marked contrast with all artificial instruments; for, in these, when properly adjusted, the image is clearly defined up to the margin of the field. By way of compensation, the eye is endowed with mobility to such an extent, and performed so instantaneously, that the bad effects of so small a field of perfect definition are almost completely neutralized, since it has the power of changing the direction of the optic axes to suit the position of an object in any portion of the large field above defined. In all perfect optical instruments we find provision made to prevent what are termed in optics, chromatic and spherical aberrations, the one due to the compound nature of the solar ray, and the other to the fact that divergent rays strike the centre and margin of lenses at different angles. By some the iris has been thought to correct these aberrations, and whilst it answers the purpose to a certain extent, as regards the latter form, it can have little or no influence in correcting the first.

Unlike the perfect artificial instruments, of which the lenses are uniform and perfectly transparent, the ellipsoid surfaces and refractory media of the eye are more or less imperfect in these respects, and thus interfere with a perfect definition of the object. The retina or screen is traversed by retinal vessels, always between it and the object, and has a spot corresponding in size and position with the optic

nerve entrance, which is entirely insensible to the stimulus of light, and hence incapable of receiving an image.

Again, we find impressions as regards colors vary very widely in individuals viewing the same object; and an explanation of this curious phenomenon is to be found in the fact that the color or tint of the so-called "yellow spot," which is the centre of vision, is not the same in all eyes, nor are all of the rays of the solar spectrum equally refracted by the crystalline lens, which, in the very aged, may even assume a decided yellowish tint, and thus deceptive impressions as to color may be formed. From this allusion to some of its optical defects, we must admit that the human eye, even in its normal condition, is by no means so perfect an optical instrument as it is often represented; yet it is obvious to every one, that the majority of people are only made conscious of the fact that they possess eyes by the constant reception of distinct and clear images of external objects, situated both far and near. Hence, the defects to which we have alluded must interfere but little with the efficiency of the organ in performing its functions.

In seeking to explain why these defects do not interfere with the perfection of vision, we find that the act of seeing is performed by a living organ, exercised under certain conditions, and endowed with certain physiological powers of correction peculiar to itself, which, to all practical purposes, neutralize, and render us unconscious of imperfections whose existence can be unmistakably demonstrated by appropriate experiments. Thus the mind instinctively ignores all impressions, except such as result from direct vision, and are formed on the yellow spot. By the faculty of accommodation, we obtain distinct images at any distance, and by that of convergence, we obtain a single image from the double organ. The other senses also assist us in coming to correct conclusions about what we see; whilst experience, and the force of habit, cause us to associate certain names with certain appearances, even when, as often happens, we may never have obtained an absolutely correct outline of the object in question.

When we turn our attention to the consideration of eyes that are abnormal, we find many defects of shape, of structure, of nervous sensibility, and of muscular power which cannot be remedied by the physiological processes which rendered unimportant the inherent defects of the normal eye. Under such circumstances, these defects become sources of discomfort and disease to the organ itself, or else become causes of perpetual errors of perception on the part of the individual. In many of these cases, by the use of appropriate lenses, errors of perception can be entirely corrected, and even disease warded off or arrested. This class of cases has of late years received special attention, and in all of the modern standard works on the eye we find that they are treated of in a chapter or section devoted to the consideration of "Diseases of Refraction and Accommodation."

As the remainder of our paper will be devoted to the consideration of the more common affections of refraction and accommodation, and the manner of correcting them by appropriate optical means, it is essential that we should enter upon the subject with a correct understanding of the meaning of these two terms, which are widely different as to their significance.

Refraction.—By the term *refraction* we refer to that passive power exhibited in every normal eye of changing the direction of rays from a luminous object at some point without, in such a way as to bring them to a focus on the retina, without any effort or participation of its muscular apparatus—the eye, in fact, being in a state of perfect rest. The word refraction has here the same significance as in optics, and its manifestation is due to the form of the eye-ball and the nature of its dioptric

media. The dioptric system which causes refraction is represented by certain media whose joint effect is that of a bi-convex lens. These media are the cornea, aqueous humor, crystalline lens and vitreous humor. The refractive power of the cornea, aqueous and vitreous humors is virtually the same, and it would be insufficient to focus even parallel rays on the retina without the aid of the lens. The axis of this system is termed the optic axis, and is represented by a line whose anterior extremity corresponds with the apex of the cornea, and its posterior extremity to a point on the retina situated between the "yellow spot" and the entrance of the optic nerve. The optic axis should be distinguished from the line which has been termed the *visual line*, by which we refer to a line of direction drawn straight from the object to the "yellow spot," and must thus make more or less of an angle with the optic axis, and cross it at some point near the posterior surface of the lens.

Now, the very first requisite for the formation of a perfect image is, that rays of light, emanating from the object observed, should be accurately focussed on the sentient layer of the retina. In order that this condition may be, under all circumstances, properly fulfilled, it is evident that there must be a constant or definite relation between the united refracting power of the various media and the length of the antero-posterior diameter of the globe. When such is not the case, the organ is said to present an anomaly, or disease of refraction. Under this head are included myopia, hypermetropia, and astigmatism.

Accommodation.—By this term we refer to that power which every normal eye possesses, of so adjusting itself that the retina shall receive clear and distinct images of objects situated at different distances. Thus we are able at one moment to recognize objects but a few inches from the eye, and, in the next, to distinguish something in the distance, or appreciate at a glance the prominent features of the most extensive landscape. In a word, the function of accommodation is one by which the refractory power of the eye is changed to correspond with the direction of rays emanating from an object, whatever may be the degree of their divergence. The function of accommodation, though a voluntary act, is unconsciously performed, the active agents participating in it having learned these duties at so early a period of infancy that through life they are instinctively performed.

Various theories have been expounded as explaining this function, and many attempts made to recognize the changes which occur in the interior of the eye during the process or act of accommodation; but it is now admitted, on the authority of Helmholtz, who demonstrated the fact by experiment, that the chief cause of the increase in the refraction of the eye is a change in the form of the crystalline lens, whereby it becomes more convex, and, consequently, of a higher refractory power, together with a shortening of its focal distance. This result is obtained, as he demonstrated, by the contraction of the ciliary muscle. There are other changes which take place in the eye during the process of accommodation, but their occurrence may be considered as incidental, and not as directly tending to increase the power of refraction. The function of accommodation may thus be said to be the result of a muscular effort on the part of a special muscle, and its effects can be neutralized by paralyzing that muscle.

Convergence.—Associated with the function of accommodation, and exercised in harmony with it, is a muscular effort termed convergence, by which the eyes are so directed that an image is formed on the "yellow spot" of each one at whatever distance the object may be situated.

Thus, whilst accommodation provides for the formation of clear and distinct images,

at all distances, in each eye, convergence provides for single vision with the two organs. The muscles effecting these two functions are controlled by branches of the same nerve (the third cranial), and, in normal eyes, these movements, though independent, are always in harmony; any attempt to disturb this harmonious relation being followed by discomfort to the individual, or failure of the effort. Now, the physiological corrections by which the defects, as an optical instrument belonging to every normal eye, are neutralized, are effected unconsciously by the action of its muscular apparatus. When these defects become so great that in the instinctive desire to correct them excessive muscular effort is required, or harmonious action destroyed, either of these results give rise to discomfort, followed by dimness of vision when the over-strained muscle is relaxed from exhaustion, and by causing intra-occular congestion, may occasion disease. In the class of affections arising from defective accommodation, are included presbyopia, paralysis, and spasm of the ciliary muscle.

Emmetropia and Ametropia.—In the normal eye, or one that is anatomically and physiologically perfect, the relation between the refractive power of the dioptric media and the length of the optic axis is such that parallel rays, or rays from an object at an infinite distance are focussed on the retina without any effort of accommodation. As a practical point we may observe, that very slight departures from parallelism of rays is not regarded by the eye, and for purposes of illustration, and in our examinations, we may consider all rays parallel which emanate from a source more than twenty feet distant. Within that distance, all rays are divergent, and images of objects thus situated would be indistinct but for the fact that the ciliary muscle contracts, and the refraction is increased to such an extent that the divergent rays are still focussed on the retina. As the object is brought nearer and nearer the eye, we at last reach a point where the effect of the ciliary muscle, in increasing refraction, is at its maximum. This is the so-called "near point" of distinct vision, within which all objects are but imperfectly seen, because the extremely divergent rays are not focussed, but form circles of diffusion on the retina. "Thus, when the eye has obtained its highest degree of refraction, it is accommodated for its near point of distinct vision ; on the other hand, when the refraction is at its lowest degree, the eye is accommodated for its furthest point." In seeking for a word to express that condition in which the relation between refraction and the length of the antero-posterior axis is such as characterizes the ideally perfect eye in a complete state of rest, and above described, Donders originated the term "Emmetropia" (from ἔμμετρος and ὤψ); and such an eye is said to be emmetropic, since the limit of refraction, in a state of rest, or the principal focus of the dioptric media, is exactly at the measure; that is, parallel rays are focussed on the retina.

The state of refraction may deviate from this normal standard or emmetropic condition in two ways, as follows:

1. The principal focus, when the eye is adjusted for its far point lies in front of the retina (myopia).

2. The principal focus when the eye is adjusted for its far point lies behind the retina (hypermetropia.)

In the first case, the antero-posterior axis of the eye is too long, or the refraction power too high: so that parallel rays, when the eye is adjusted for its far point, are brought to a focus in front of the retina; in fact, the furthest limit of the principal focus lies within the normal measure. To this condition it was proposed to give the name, brachymetropia (βραχυς, μετρον and ὤψ) but the old term,

myopia (μυω), referring to the habit which near-sighted persons have of nipping the lids together to diminish the effect of circles of diffusion, has, by common consent, been retained in this connection. In a state of rest, then, the myopic eye is adjusted for *divergent* rays, since parallel rays are focussed in front of the retina. In the second case, on the other hand, the refracting power of the eye may be too low, or its antero-posterior axis too short; so that, in a state of rest, parallel rays are brought to a focus behind the retina. Here the furthest limit of the principal focus is beyond the measure, and this condition is referred to by the term hypermetropia (υπερ μετρον ωψ.) Thus, in a state of rest, the hypermetropic eye is adjusted for *convergent* rays, since those which are parallel are focussed behind the retina. A departure from the normal or emmetropic condition in either direction is referred to by the term *ametropia.*

Whilst the anomalies of refraction may be strictly resolved into the two forms of myopia and hypermetropia, owing to a want of symmetry of the different surfaces, the refractive power of the dioptric media may not be the same in all meridians of the same eye; thus, whilst rays refracted in one meridian may unite and form defined images on the retina, those, passing through another meridian, may unite either before or behind the retina, forming either widened or elongated figures of dispersion, which render the total impression indistinct. Such an eye has no distance of distinct vision, all objects being seen with circles of diffusion, and the condition is expressed by the word astigmatism (α and στιγμα), which signifies that rays emanating from a point are not re-united or focussed at a point, the dioptric media as a whole having no definite focus. Thus, an astigmatic eye may be emmetropic in the vertical meridian, and either myopic or hypermetropic in the horizontal meridian or *vice versa;* or there may be a difference of degree, or even of the form of ametropia in the various meridians. Even in the normal eye, owing to the ellipsoid shape of the anterior surface of the cornea, the refractive power is not exactly the same in the vertical and horizontal meridians with many individuals, but this difference is not sufficient to interfere with distinct vision.

Range of Accommodation.—In the foregoing remarks, we have alluded to the fact that when the refractive power of the eye was at its lowest degree the organ was accommodated for its furthest point of distinct vision; from which we conclude that in emmetropic eyes the furthest point of distinct vision lies at an infinite distance. In myopic eyes it is limited by the degree of myopia, and in eyes absolutely hypermetropic there is really no point of distinct vision without the aid of glasses. When the refractive power of the eye is at its highest degree, the organ is accommodated for its nearest point of distinct vision. In the normal eye the situation of this near point is governed by the power of the ciliary muscle to increase the convexity of the crystalline lens, and, in the young subject, this power is usually sufficient to bring it about three and a half or four inches from the eye. Now the distance between the furthest point and the nearest point of distinct vision is called the range of accommodation The extent of this territory of distinct vision or range of accommodation will vary in each case in accordance with the strength of the ciliary muscle and its effect in changing the convexity of the lens.

Owing to certain physiological changes, increasing its hardness and diminishing its elasticity, which take place sooner or later in the lens of every eye, the power of the ciliary muscle to produce the requisite increase of convexity is diminished, and thus, with advancing years, the near point recedes from its former position.

This retrocession resulting from physiological changes in the lens, begins as early as the tenth year and progresses with the age of the individual, but causes no inconve-

nience until small objects have to be held at such a distance from the eye that they become indistinct by reason of the small size of their retinal images. This usually occurs about the age of 40 or 45 years, and about that time we find that the near point has receded beyond eight inches, so that this distance being assumed as a standard, a person whose near point is beyond it is said to have presbyopia or old sight. This change in the position of the near point occurs in all healthy eyes, whether they be emmetropic, myopic or hypermetropic, and is alluded to just here, because it was formerly supposed that, inasmuch as presbyopia and myopia required positive and negative lenses respectively for their correction, they were opposite conditions or affections; but from what has been said, it is evident that such is not the case. In myopia, the position of the far point is abnormal; in presbyopia, the position of the far point is normal, but that of the near point is removed further from the eye with advancing years. Thus, whilst myopia is an anomaly or affection of refraction, presbyopia is only a diminution or narrowing of the range of accommodation by which the near point is so far removed that the retinal image of small objects situated at it is rendered indistinct.

Visual Angle and Test Types.—Before treating at length of the affections which we have just defined, and of the means by which they are corrected, it is proper that we should allude to the manner in which we arrive at some standard of perfection of vision to which we may refer all departures from the same, and the mode in which these departures may be indicated by a numerical scale which at the same time gives us a clue to the number of the lens which corrects them when due to faulty refraction or accommodation. The apparent size of any object at which we look depends upon the size of its retinal image, and the size of this image depends upon the distance of the object, the same object having a smaller image the greater the distance it is from the eye. The angle made by the intersection within the eye of the lines of direction passing from the object to its image on the retina, is termed the visual angle, and ot course it has a constant relation to the size of the object and its distance from the eye, being smaller, the less the size of the object or greater the distance, and *vice versa.* The smallest angle at which objects of known size and form can be recognized, determines the acuteness of vision. It having been determined by actual experiment that the smallest visual angle under which objects could be distinguished by the normal eye was one of five minutes, that was taken as the standard for testing the acuteness of vision, and the test types of Snellen, most commonly in use, are made on this principle, each letter being seen under an angle of five minutes at the distance in feet corresponding to its number. Thus, No. 1 is seen under an angle of five minutes at one foot, No. 20 at 20 feet, etc. A visual angle and corresponding distance being assumed as the unit or standard of measure, the proportion between such distance and that at which the object is really seen, would express the acuteness of vision in a given case. In the case of Snellen's types, the recognition of letters seen under an angle of five minutes being taken as the unit of comparison, "the utmost distance at which the types are recognized (d) divided by the distance at which they appear at an angle of five minutes (D), gives the formula for the acuteness of vision (V)"—$V=\frac{d}{D}$ Thus, if No. 20 be seen at 20 feet v=20-20 or 1, the normal standard; if No. 20 be seen only at 15 feet v=15·20=$\frac{3}{4}$; if No. 5 be read only at 1 foot v=1-5, and so on. Sometimes the actual may exceed the standard distance, and thus the acuteness of vision would be above the average. The normal acuteness of vision has been found to decrease with age for several physiological reasons, and from a series of experiments it was found to vary quite extensively at different periods of life. Thus, at the age of

10 years, the average ratio was as 22.5 to 20: at 30, as 22 to 20; at 40, as 20.5 to 20; at 50, as 18 to 20; and at 80, as 11 to 20.—(*Snellen*).

The magnifying power of positive lenses, and the refracting power of both positive and negative lenses, is inversely proportionate to their focal lengths. Thus, the magnifying power of a convex lens whose focal length is three inches, is greater than that of one whose focal length is six inches, and the same may be said of its refracting power. In order to demonstrate this fact, and to correctly express the relative power of a given lens, we number and refer to it by its reciprocal or fraction, of which the numerator is one and the denominator its focal length in inches; thus, a lens of $\frac{1}{3}$ is stronger than one of 1-6, the former fraction being larger than the latter. Now, the degree of ametropia in any case is expressed in a numerical method by the power of the lens which corrects it. A myopia or hypermetropia, which is corrected by a 1-6 or 1-10 concave lens in the one case, or by a 1-6 or 1-10 convex lens in the other, is described as a myopia or hypermetropia of 1-6 or 1-10—a mode of expression which reminds us that the defect requiring the glass of 1-6 is greater in degree than that requiring the glass of 1-10.

Myopia.—This trouble is frequently congenital, and often hereditary. The most frequent cause of it is an abnormal length of the antero-posterior axis of the eye-ball; and this increase in length is chiefly due to a bulging at the posterior pole. This condition is usually accompanied, almost always when the myopia is excessive, by a thinning and atrophy of the choroid at the seat of the bulging. Evidence of this fact is revealed by the ophthalmoscope, by which we detect the white color of the sclerotic through the thinned or atrophied choroid, in the shape of a white crescent bordering on the optic nerve entrance.

The characteristic symptom of this affection is a diminution of the distance of the far point, and consequent inability to see distant objects without the aid of concave glasses. The distance of the far point may vary in different cases, and we may have various grades of myopia expressed by the refractive state of the eye; thus, by a myopia of 1-10 or $\frac{1}{6}$, we mean that the far point is distant 10 or 6 inches, as the case may be, and the trouble is corrected by the corresponding number of concave lens. It is customary to describe myopia as of *low* grade when the far point is beyond 14 inches; as *medium* when it is between 14 and 6 inches; and as *high* when inside of 6 inches. We have already alluded to the harmonious relation existing between the muscular efforts required for accommodation and for convergence in normal or emmetropic eyes. Now, a person whose myopia required a concave lens of 6 inches focal length for its correction, would use no accommodation at all to look at an object six inches distant, though the muscular effort for convergence would be exerted to the proper degree for such proximity. Here the degree of convergence is greatly in excess of the accommodation, and the natural or normal relation between the two functions does not exist. In low forms of myopia, the constant requirements of the individual render him insensible or unconscious of the exercise of a great degree of convergence corresponding with his far point, and which in his case may be considered as equivalent to parallelism in normal eyes. Hence, the ordinary use of the eyes is not followed by any sense of muscular fatigue or straining, though the defective vision is apparent.

In a case like that previously supposed, when the degree of myopia was *high*, or when the object for any reason was brought much inside of the far point, the defect of vision would not only be apparent, but the use of the eyes for any length of time at so close a distance would be followed by a sense of straining or fatigue resulting from

excessive convergence. The strong convergence of the optic axes under such circumstances, causes congestion of the inner tunics of the eye-ball, and the increased pressure on the occular contents has a tendency to distend their investments at their weakest point, thus increasing the length of the antero-posterior axis by causing a bulging near the posterior pole. This giving way of the tunics, referred to by the term *posterior staphyloma*, is favored by the relaxed condition of the choroid, consequent upon the relaxed condition of the muscle of accommodation, one of whose functions, it has been claimed, being to render tense that membrane. From what has been said, it is evident that in high degrees of myopia, there we not only have inherent causes for its progressive increase, but in many cases for absolute disease.

Whilst it is not in our power ever to cure myopia, since it is impossible to remove the cause, we can, in many cases, improve vision, and prevent increase of the trouble, with its accompanying pathological changes, by the use of lenses which correct the defective refraction, and establish, as far as possible, harmony between the muscular efforts of accommodation and convergence. It having been determined by observation that myopia resulting from elongation of the optic axis may become decided at the early age of five years, it is highly important that its existence in childhood should be detected, since a knowledge of this fact ought to have an influence on the mode of education and future choice of a profession by the individual.

In order that the full advantage of their use may be realized, it is necessary that the glasses of myopic persons should be selected with accuracy and with due regard to the peculiarities of the muscular apparatus of each individual. When applied to, we should first of all determine the exact distance of the far point, which establishes the degree of myopia, and at once gives us a clue to the proper glass for the case. For example, a person applies who can only read No. 200 Snellen, at 20 feet—evidence of the fact that he cannot see at a distance. We next try him with him No. 1, and find that he can read it up to 10 inches with readiness, thus determining his far point and degree of myopia, which in this case=1-10, since a concave lens of 10 inch focus would render parallel rays as divergent as if they came from a point distant 10 inches in front of it. For practical purposes, in the low grades of myopia, we may fail to consider the distance between the lens and the eye in the majority of cases; but in high degrees of myopia, and for the greatest degree of accuracy, this element should enter into our calculations. This distance of the far point, then, gives us a clue as to the proper glass, which in this case would be concave 10. Theoretically, No. 10 would be the proper glass, but practically it would be rather too strong and produce muscular discomfort, because the eye is unable to accommodate itself for its far point except when looking at distant objects with parallel optic axes. It would be found that a weaker glass, say No. 12, would answer better in the above case. In order to prove that No. 12 is really the glass best suited for the patient, we must alternately place before it very weak convex or concave lenses, and observe the effect. If vision is improved by the addition of weak concave lenses, the ones selected are not strong enough; and if improved by the addition of convex lenses, they are too strong. If the addition of neither convex nor concave lenses improve the sight, the original glass was the proper one. As a general rule, in selecting concave glasses, we should endeavor to give the patient the *weakest* pair that will enable him to see distinctly at a distance, so as to reduce to a minimum the effort of accommodation when the eyes are directed to near objects, since it is not often that we are required to look for any length of time at any distant object, but to regard at one moment objects near at hand, and in the next something in the distance. The question is often asked, if the

use of concave glasses does not tend to increase the myopia, and thus really result in injury to the sight? In a paper like this, it would be impossible to discuss at length the reasons which, in the great majority of cases, would induce us to give a negative answer to such a question; but the following general rules may be of practical value in assisting the practitioner to give proper advice in a given case: When the myopia is of low degree, and the range of accommodation good, we may advise the use of glasses which completely correct it, for distant and even for near work with young subjects. When the myopia is very high, say from 1-10 to 1-5, it is best not to correct it entirely for distant objects, but to allow the use of glasses which ordinarily remove the far point to 14 or 16 inches, and make use of an additional eye-glass before the spectacles when distant objects are to be closely examined. For all educational work, when the myopia is greater than 1-10, it is of the greatest importance that glasses should be used which prevent undue approximation of the book and stooping posture of the body, since the excessive convergence in the one case, and position of the body in the other tend always to cause intra-ocular congestion and its attendant evils. In myopia of high degree, the prolonged and excessive effort of convergence sometimes results in the impairment of muscular power, which is described as "insufficiency of the internal recti muscles," manifested or accompanied by a sense of aching after prolonged use of the eye on close work. In some cases, the myopia is so great that the eyes have instinctively relieved themselves of the strain of excessive convergence at the expense of binocular vision, the person using only one eye at a time for reading, &c., and manifesting a divergent squint for objects at his ordinary visual distance. In cases of "insufficiency," the tone of the weakened muscles can often be improved by appropriate exercise with prismatic lenses, whilst the myopia can be corrected by the proper spectacles. When from excessive myopia binocular vision has been sacrificed, it is rarely possible to restore it even with glasses; and under such circumstances, whilst the use or not of a glass for the eye used on near objects may be left to the instincts of the patient, a single glass for the other eye will contribute much to his comfort in looking at distant objects.

In conclusion, a most important piece of advice which should always be given to myopic persons, is, to keep the work or book at the farthest possible distance from the eye compatible with distinctness of vision, as by so doing they diminish the muscular effort required for convergence, and avoid as much as possible the congestion incident to the stooping posture. The young and those who study are especially to be cautioned on this point, since with them there is always a tendency to diminish the reading distance and obtain larger retinal images when the illumination is imperfect, or type indistinct.

Hypermetropia.—By this term we define a condition exactly the opposite of myopia, that is, either the refracting power of the dioptric media is too low, or else the antero-posterior axis of the globe is too short; so that, in a state of rest, parallel rays are united behind the retina, only *convergent* rays being focussed on it. In consequence of the low refracting power or shortening of the optic axis, hypermetropic eyes have to exert a certain amount of accommodation even for distant objects. This exercise of the accommodation increases of course in direct ratio with the proximity of the object; and whilst the power of the ciliary muscle may be sufficient to overcome moderate degrees of hypermetropia, this result is accomplished with a disturbance of harmony between the efforts of accommodation and convergence. The hypermetropic person is continually exerting a degree of accommodation greatly in excess of his convergence; and hence, whilst with the myope we notice frequent failure

of the muscles of convergence, it is in the muscle of accommodation that we observe a loss of power in the case of the former. Like myopia, this affection is often congenital and hereditary, the most frequent cause of it under such circumstances being a faulty formation of the globe by which the antero-posterior axis is shortened. It may also be caused by senile changes in the lens, or by absence of the lens, from whatever cause; thus the trouble may be either original or acquired. The degree of hypermetropia is expressed, like that of myopia, by the power of the lens required to correct it. The ciliary muscle may be able to neutralize all or a portion of the trouble in a given case; hence we have two forms of hypermetropia—the *latent* and *manifest*—the latter indicating that portion which is apparent in spite of the utmost effort of the muscle to neutralize it, and the former that which is neutralized or concealed by muscular effort. The mode of procedure in testing a case of suspected hypermetropia is as follows: We first try the patient with No. 20, Snellen, at 20 feet. Should he read it with ease, we next find the strongest convex glass with which he can still distinguish the letters at the same distance. The power of this lens gives us the degree of his *manifest* hypermetropia. Each eye should be separately tried, as they may not be affected to the same extent; and we should at the same time determine the near point and range of accommodation with the glasses selected, since the age of the patient would have some influence in these respects. Let us suppose in a given case that our patient could read No. 20 without glasses, and also with a convex lens up to 1-24. His manifest hypermetropia then = 1-24. Owing to the fact that he has been accustomed to exert a certain amount of accommodation even for distant objects, now, when there is no longer occasion for it whilst using convex glasses to correct any faulty structure of the globe, he finds it impossible to completely relax the muscles of accommodation. Hence, to detect the degree of *latent* hypermetropia, it becomes necessary to paralyze the ciliary muscle by a strong solution of atropine. After using the atropine, we would most probably find our patient unable to read No. 20 at 20 feet with convex 24, but now requiring convex 12 to read at that distance. The difference between the strength of the lenses used before and after paralysis of the ciliary muscle, gives us an idea as to what extent the accommodation was constantly exerted, and how much of his hypermetropia was rendered *latent*. In the case just considered, we have acted on the supposition that our patient could read No. 20 at 20 feet *without* glasses as well as with them, and could also read No. 1 at the proper distance under the same conditions. Such, however, is not always the case, and hence the division (after Donders) of manifest hypermetropia into three forms or varieties, the *facultative*, *relative*, and the *absolute*, recognized by the following symptoms and characteristics:

1. In facultative hypermetropia, vision is good for infinite distance with parallel axes, with or without convex glasses, and sufficiently acute to allow the patient to read or work at fine objects. In such cases, the disturbance of harmony between the efforts of accommodation and convergence is not sufficient to cause any strain or uneasiness, and the patient may never become aware of his defect, until the early invasion of presbyopia, with symptoms of asthenopia, cause him to seek relief.

2. In relative hypermetropia, the patient can accommodate the eye for infinite distance and for near objects also, both for parallel and for divergent rays, and thus sees comparatively well both far and near. This result, however, is obtained by converging the optic axis for a point nearer than that at which the object is situated, thus giving rise to a periodic convergent squint. The refractive power being increased by the excessive effort of convergence, this is kept up often to the extent of causing a permanent squint, or even at a sacrifice of binocular vision. In this class of cases, distinctness of vision is nearly always more or less impaired.

3. In absolute hypermetropia, the individual is unable to accommodate the eye for either parallel or divergent rays, and of course vision is not distinct without glasses at any distance. Here, the strongest effort of accommodation, associated with the utmost degree of convergence, fails to focus parallel rays, much less divergent ones, on the retina. From not being able to see at a distance, and from the fact that they bring small objects close to the eye in order to increase the size of the retinal images, such patients at first sight might be supposed to be myopic; or else from the fact that they cannot see very fine print at the usual distance, amblyopia might be suspected until the difficulty is found to be corrected by appropriate glasses.

From what has been said, we can understand how in all three forms of this affection the muscle of accommodation is never at rest unless the eyes are closed, since the instinctive desire for definite images compels more or less exercise of it at all other times. Whilst the power of accommodation is full and active, and the degree of hypermetropia slight, distant vision may be obtained as in the first two forms, without any sense of fatigue or discomfort. When the power of accommodation is impaired by age or general debility, the muscular strain required for distinct vision is often so great as to cause intra-ocular pain and discomfort, and the relaxation of the muscle from exhaustion or pain is followed by dimness of vision proportionate to the degree of hypermetropia. This affection, then, is a frequent cause of weak sight and discomfort, associated with intra-ocular congestion, arising from a disturbance of harmony between the efforts of accommodation and convergence, and it is also a frequent cause of convergent strabismus, binocular vision being sacrificed to obtain the greater power of accommodation, which accompanies contraction of the internal recti muscles.

Treatment.—Theoretically, it would appear proper to neutralize any existing hypermetropia by suitable convex glasses, and thus change the eye into an emmetropic one; but experience teaches us that such a course is not always best in practice. It has been found best not to advise glasses for distance in facultative hypermetropia, since the patient sees well at a distance without them, nor for near objects either, unless symptoms of asthenopia are present. In the relative and absolute forms, spectacles should be worn for distance, which correct the manifest hypermetropia, and a stronger pair or an additional eye-glass should be used for reading and close work. We have alluded to the manner in which the excessive effort of accommodation required for distinct vision in relative hypermetropia may sometimes entail a permanent convergence of the optic axis or strabismus convergens. The muscular derangement in such cases requires a surgical operation for its relief, and a perfect and permanent result is often only to be obtained by subsequent exercise of the faulty muscles with prismatic lenses, success depending as much upon the theoretical knowledge as upon the manual dexterity of the operator.

Astigmatism.—In a previous portion of this article, we have defined this term as one applied to that condition of the eye in which the refracting power was not the same in all of its meridians, and hence as a whole the eye had no exact focus. When this condition exists to any considerable degree, the effect is to cause the eye to exert a different degree of accommodation for each aspect or portion of the object observed. Thus, in the case of an eye which was more hypermetropic in the vertical than in the horizontal meridian, the effect would be as if the horizontal boundaries of an object or letter were nearer than the vertical, since they would require a greater effort of accommodation to cause them to form distinct images in the retina. Under such circumstances, in reading, each letter would have to be defined, first from those which precede and follow it, and then from those above and below it, which can only be

done by a change in the accommodation. In the course of time this constant change of the accommodation must be followed by muscular exhaustion and relaxation, and consequent indistinctness of vision.

In the above remarks, we have assumed that the meridians of maximum and minimum refraction, or of maximum and minimum curvature of the cornea, corresponded with the vertical and horizontal meridians of the globe; but such is not always the case, as we find in practice that they may deviate considerably from these directions, and yet always be at right angles to each other. This affection may be either congenital or acquired. In the former case it is usually dependent on a want of symmetry of the surface of the cornea. Acquired astigmatism is usually due to inflammatory changes in the cornea, followed by fattening, or to irregularities of the corneal surface, resulting from surgical operations; or it may be caused by dislocation of the lens or peculiarities of its structure. In all cases where the aberration is due to a difference in the focal length of the two principal meridians, it depends upon the peculiarities of the curvature of the cornea, and is termed *regulara stigmatism*. When there is a difference in the focal length of different portions of the same meridian with consequent aberration, it is termed *irregular astigmatism*, and is usually due to some defect in the structure or position of the crystalline lens.

There are several methods of testing for astigmatism, but the simplest is that in which the test object consists of a series of straight lines of a definite size crossing each other at the centre of a circle. The test object being placed at the proper distance, and any existing myopia or hypermetropia being corrected as far as possible by suitable spherical glasses, if the patient can see all of the lines with equal distinctness, no astigmatism is present. If, now, one line only is sharply and distinctly defined whilst the others are more or less indistinct, astigmatism exists, and the direction of the distinct line indicates the meridian of highest refraction. In order to determine the nature and degree of the astigmatism, we find the weakest concave or strongest convex lens which with the stenopaic plate,* renders all of the lens equally distinct. If a concave lens effects our object, the case is one of myopic astigmatism; and if a convex lens is required, it is hypermetropic. In many cases the diagnosis of astigmatism is readily made, but in others it is extremely difficult, and requires considerable practical experience with the subject. To enter fully and in detail upon the consideration of the various forms of astigmatism, the mode of their detection and correction would, extend the length of this paper too much, and defeat the object for which it was intended; so our remarks upon the treatment will be confined to a simple description of the principles upon which it is based, and details upon the subject can be found in the modern standard works on the eye.

Regular astigmatism may be corrected by the use of cylindrical lenses, which correct the faulty refraction in each of the principal meridians, whilst irregular astigmatism cannot be remedied by this means. The convex and concave lenses used for the correction of hypermetropia and myopia, and referred to in the description of these affections have been supposed to be segments of a sphere and rays of light are equally refracted by them, in all planes of the segment. A cylindrical lens is a segment of of a cylinder, and it refracts those rays the most which infringe upon it in a plane at right angles to the axis of cylindrical curvature, whilst those rays which pass through a plane corresponding with the axis undergo no refraction whatever. A knowledge of the optical properties of cylindrical lenses gives us a clue as to the method of placing them in spectacles designed to correct astigmatism. Thus, if one principal

*Circular plate with a slit in it.

meridian is normal and the other myopic or hypermetropic, the faulty refraction would be corrected by an appropriate concave or convex cylindrical lens with its axis corresponding to the normal meridian. As a general rule, "a convex cylindrical lens should be placed in such a direction that its axis lies in the plane of the highest refracting meridian, in order that it may give to the rays which undergo the smallest degree of deflection (smallest curvature) such an increased amount of convergence as if they passed through the meridian of highest refraction. The reverse obtains in the case of concave cylindrical lenses, for here the axis must correspond to the meridian of least refraction, so that the focal length of the meridian of greatest curvature may be increased and made equal to that of the meridian of least refraction."—*Wells*. Practically, it is not always desirable to completely correct the faulty refraction in cases of astigmatism, and we have to be content with a partial neutralization of the hypermetropia or myopia, for fear of disturbing too much the harmony between the muscles of accommodation and convergence, and the evils attendant on such a course. In cases of irregular astigmatism, cylindrical lenses fail to correct the trouble, and we may here improve vision by the use of stenopaic spectacles, which exclude the greater portion of the irregularly refracted rays, and thus diminish circles of dispersion.

We cannot conclude our imperfect remarks upon the anomalies of refraction without alluding to the great influence they have exerted in establishing the fame of more than one artist of renown, whose physical defect proved indeed a blessing in disguise. Many of the wonderful effects of distance in landscape painting, which excited the admiration of all art critics, and established a peculiarity of style that was beyond imitation, have been simply due to some anomaly of refraction, the artist only representing nature as it appeared to his defective vision. In this connection, our subject has recently acquired additional and popular interest in consequence of a lecture delivered at the Royal Institute, London, March 8, 1872, by Professor Leibrich, the celebrated ophthalmologist, in which he accounted for the great difference in style between the early and late works of Turner, a celebrated English landscape painter, by demonstrating the fact that with advancing years that artist had become the subject of acquired astigmatism. This lecture was republished in Appleton's "Popular Science Monthly" for June, 1872, and is worthy of the world-wide fame of its eminent author.

Presbyopia.—The simplest and most common affection of the eye that can be corrected by optical means, is one in which the fault is to be found in the function of accommodation, whilst that of refraction remains intact. This condition has already been defined by the term presbyopia, or old sight, and is characterized by a narrowing of the range of accommodation, the near point being removed so far from the eye as to cause a difficulty in distinguishing small objects because of the small size of their retinal images. In this affection, the gradual hardening of the lens from age, requires a constantly increasing effort of accommodation to produce a given effect, whilst there is no necessity for a corresponding increase in the effort of convergence. The result is a disturbance of harmony between the two muscular efforts, giving rise to sensations of pain and aching, when the instinctive desire to obtain distinct images is gratified. The first evidence of presbyopia is, that small objects cannot be clearly seen, though near at hand, whilst distant vision is as perfect as ever. If the attempt to see small objects near at hand is persisted in, it is followed either by failure or by unpleasant sensations of straining. In order to appreciate the meaning of these phenomena, let us suppose a case in which the reading distance of an individual in the prime of life is eighteen inches; in other

words, that equal efforts are exerted for accommodation and for convergence at that distance. Should presbyopia supervene, we would find that such a person would require as much effort of accommodation to see distinctly at eighteen inches as would formerly have given distinct vision at a shorter distance, say twelve inches. If the reading distance of eighteen inches is maintained, the accommodation effort must be increased one-third, whilst the convergence remains the same. If now he only exerts his original accommodation effort, and appreciating its diminished effect in changing the form of the lens so as to increase its converging power, moves the book to twenty-seven inches, he at the same time must diminish his convergence effort one-third, in order to get clear images. In either case the natural harmony of the two functions is disturbed to obtain distinct vision, and the result is, first, pain from this disturbance, and then indistinctness of vision from inability to keep up the muscular strain required under such conditions.

We have already stated that the hardening process of the lens, and consequent removal of the near point was common to all eyes, whatever might be the original condition of their refraction; and we have also alluded to the fact that the retrocession of the near point usually causes no inconvenience until it passes beyond eight inches. These conclusions are the result of observation on the part of Donders, who advises that we should consider all eyes presbyopic when the near point of distinct vision is beyond that distance. Having assumed a definite distance as the commencement of presbyopia, we are enabled to express its degree by the power of the lens which corrects it; that is, would bring the near point back to eight inches. Thus, if in a given case, the near point of a presbyopic person was sixteen inches, the degree of his presbyopia would be expressed by the formula— Pr. $=\frac{1}{8}$—1-16 = 1-16, or, in general terms, Pr. $=\frac{1}{8}$—1-n, ~~so~~ representing the presbyopic near point in each case; and the amount of presbyopia being designated by the power of the lens which brings the near point to eight inches. The effect of a convex lens placed on the outside of the eye is to render unnecessary an amount of increased convexity of the crystalline lens proportionate to the strength of the external lens, and to this extent it renders unnecessary accommodation effort, and relieves muscular strain. A knowledge of these optical effects enables us to understand the rationale of the use of convex lenses in presbyopia, and the relief which they afford to the wearied muscles of accommodation. The public generally, and very often medical men, are under the impression that the use of glasses for presbyopia should be avoided as long as possible, for fear that their use would increase the trouble, or else become indispensable to the comfort of the wearer. This idea is manifestly incorrect so far as regards any increase of the trouble arising from the use of the glasses; for we find that, if presbyopic persons continue fine work and reading, without glasses, their trouble rapidly increases, and there can be no doubt of the propriety of allowing our patients to wear suitable glasses so soon as any inconvenience is caused by their presbyopia. In adapting spectacles for presbyopic patients, we should find the near point of distinct vision by measurement, and then, by the formula above given, we determine the degree of presbyopia, and the number of the glass required for its correction. The lens thus found would be theoretically the correct glass; but in practice we find that it is generally too strong, as such glasses would really bring the near point closer than eight inches, in view of the greater degree of convergence of the optic axes for that distance. We should also be guided somewhat by the extent of the range of accommodation, as the greater it is, the nearer we come to using glasses which bring the near point to eight inches. As a general rule, however, in eyes simply presbyopic we should

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select the weakest glasses that enable the patient to read No. 1 distinctly at twelve inches, and at the same time with comfort. In many cases, for steady and prolonged work, we may have to be satisfied with a still greater distance, as the effect of convergence for a shorter distance, if prolonged, may give rise to unpleasant sensations. Presbyopia, as a rule, being a progressive trouble, it will be found necessary, from time to time, to increase the strength of the glasses worn; but in changing, care should be taken that they do not relax the accommodation too much. In many cases, even where there is no manifest tendency to cataract, senile changes in the lens diminish its perfect transparency, and cause slight amblyopia, which fact should be remembered in advising a change of glasses. On the other hand, rapidly increasing presbyopia should always receive our careful attention, in view of the fact that sometimes it is one of the earliest symptoms of one of the most serious affections to which eyes are liable, the subacute form of glaucoma.

Difference in the Refraction of the two Eyes.—In the vast majority of cases we find that the refractive power of the two eyes is the same; but sometimes, in cases of ametropia, the trouble is different, either in degree or in form, on the two sides, or, one eye may be emmetropic and the other myopic or hypermetropic. The relief of such cases, by the use of glasses, presents some practical difficulties, because of confusion arising from the different size of the retinal images when these agents are employed. When there is a difference in the degree of myopia or hypermetropia, it has been found best to furnish both eyes with a lens which corrects the trouble in the eye least affected, or else endeavor to partially correct the defect in both eyes by suitable lenses, and thus diminish to some extent the difference in the size of the retinal images. When the greatest possible accuracy of vision is desired, we may use two different glasses which completely neutralize the defect in each eye; and practice alone will demonstrate whether or not they can be worn to advantage and with comfort. When there is a difference in the form of the trouble in the two eyes, one being myopic and the other hypermetropic, it is still more difficult to correct the anomaly, since the convex lens will enlarge and the concave diminish the size of the retinal image; and this fact may still further increase the confusion of vision. We should always allow such patients to try spectacles for a sufficient length of time for the eyes to become accustomed to the new condition of affairs before deciding finally on the exact number and kind of glass to be worn, as no general rule will apply in all cases of this character.

In these days, when the country is overrun by travelling "Professors of optics," who often succeed in deceiving the educated as well as the ignorant by their representations of magical virtues possessed by the peculiar make of spectacles which they vend, it is well to close an article like this with a brief allusion to the most common form of lenses used for the correction of the troubles which have been considered in the preceding pages.

The most common form of spectacles worn for defective sight are those which are fitted with spherical lenses, double convex or double concave, as the case may require. In the correction of astigmatism, cylindrical lenses are used, or a combination of the latter with one of the former kinds. A popular form of lens is that called the periscopic, which is a spherical lens; but concavo-convex, or convexo-concave, instead of double concave or double convex. By this combination of surfaces, spherical aberration is diminished, and the wearer is enabled to look more obliquely through them. These lenses are usually heavier than the ordinary spherical forms, and requiring much greater accuracy of construction, they are consequently more expensive. For the purpose of correcting double vision from paralysis

of some one of the ocular muscles, or for the purpose of exercising or relieving certain muscles, *prismatic* glasses are used, either with or without some form of spherical lens. In all cases it is of the greatest importance that spectacles should be accurately fitted, so that the centre of the lens should be opposite the centre of the pupil, else they act more or less as prisms. Hence, as a rule, circular are preferable to oval shaped lenses, since they are more easily adjusted in this respect, and spectacles are preferable to eye-glasses for continued use. The use of single glasses should be avoided in most cases, since the retina of the other eye may loose its sensibility from disuse.

In the relief of presbyopia, the spherical double-convex lens is that most commonly in use, and the range of distinct vision through such a lens is limited by its focal length. Presbyopia being usually a progressive affection, the convex lens, which at first remedies the defect by rendering unnecessary just enough effort on the part of the ciliary muscle to restore harmony between the efforts of accommodation and convergence, after a time becomes too weak, and a stronger one is required. The use of the stronger lens diminishes the range of distinct vision; but the objeet being brought close, clear images are obtained. At the same time the convergence must be increased, and if the lens is very strong, this effort of convergence may of itself be a source of discomfort. In order to relieve the strain on the muscles of convergence incidental to the use of strong convex lenses for presbyopia, Dr. Scheffler, of Brunswick, conceived the idea of having convex lenses ground on prisms whose angular measurement had a definite relation to the focal length of the lens, and to these he gave the name of orthoscopic spectacles. If the object is held at the focal length of such glasses, whilst there is relief of accommodation from the convex form of the lenses, the fact that they are also prisms, with bases toward the nose, does away with the necessity for any extra effort of convergence. The effect of such spectacles would be the same as if the person was to look with both eyes through a lens of about four inches diameter, the centre of the lens being held opposite the root of the nose. As the large lens would form only a single image at its focal length, so would the two portions through which the eyes look form only a single image, if cut away from the rest of the lens and placed in frames so that their former relative position was maintained. Thus, the peculiarity of the orthoscopic spectacles consists in the fact that the two lenses are segments of a large lens of the prôper focal length. Such glasses require great accuracy in manufacture, in the first place, and perfect adjustment of the frames to suit the distance between the eyes; so that although their optical effect is perfect when the object is held exactly at their focal length, the practical difficulties in the way of obtaining them are such as to cause their use to be limited up to this time.

As regards the material of which spectacle lenses are made, it is not so much a matter of consequence as to whether they be of glass, or of the natural pebble or crystal. For distinct vision it is essential that they should be accurately ground, and free from all impurities or coloring matter that would tend to produce chromatic aberrations; and if there is any practical superiority in the so-called pebble lenses, it is due to their greater hardness, and hence the less their liability to be scratched, or their surface injured by the many accidents which befall spectacles as well as eyes. As a rule, the spectacles sold in the shops are not ground on any uniform scale, and hence they are not numbered alike by all manufacturers. By remembering the fact that parallel rays of light are united by a convex lens at its principal focus, we can, by a simple process of measurement, always get the focal

length of such a lens in English inches, and thus readily determine whether or not our patients have been furnished with the glasses ordered. The strength of a concave lens can be determined by the number of the convex lens that is neutralized by it. For the accurate adaptation of spectacles in many cases, it is requisite that the surgeon should be provided with a case of "trial glasses," in order that he may practically verify the correctness of his deductions before making a prescription to be filled by the optician. The cases most commonly in use are those made by Nachet, of Paris, and by Paetz & Flohr, of Berlin; and whilst in some respects that of Nachet is most complete, the one of Berlin make has the advantage of the lenses being ground on the scale of the Prussian inch, which is practically the same as the English, whilst the French inch is somewhat longer. Hence, for use in our country, we would recommend the Berlin case, which also has the advantage of being less costly; and when we write our prescriptions in the English inch, a very little instruction previously given to the local optician or jeweller, will enable him always to fill them with accuracy.

In conclusion, we would state that we have attempted to condense in the preceding pages the most prominent facts established in regard to the nature and treatment of diseases of accommodation and refraction, endeavoring, at the same time to make an article, the reading of which would not be too great a trespass on the time of the Society, and one whose length, if published, would be a favorable recommendation to the general practitioners of our State. Should our imperfect effort excite an interest in the minds of any of our brethren that require further gratification, our chief object is accomplished, and they are referred to the standard works of Wells, Stellwag, and of Donders, the latter published by the Sydenham Society, and to an article on the Hygiene of Vision, by R. B. Carter, in the "Practitioner," during the summer months of 1871, as the sources from which this paper was compiled, and where these matters are exhaustively treated.